Naval Research Laboratory
Stennis Space Center, MS 39529-5004

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The Development of a World Wide Web Site for the SHOre-zone data RESolution (SHORES) Program

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August 25, 1995

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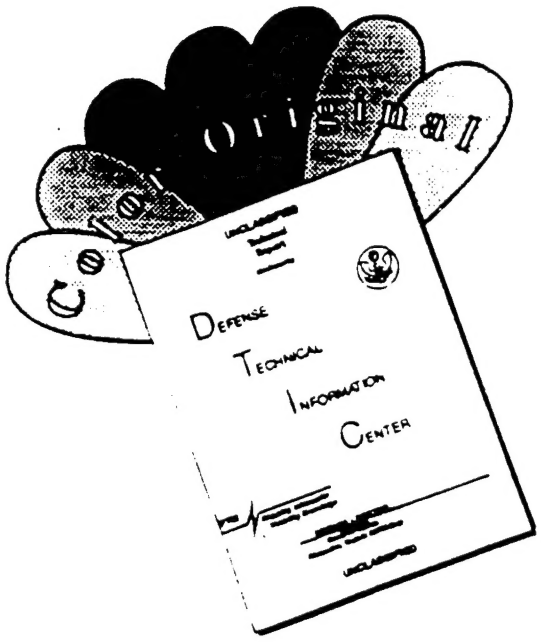

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13. ABSTRACT *(Maximum 200 words)*

The use of spatially referenced scientific and operational data has provided invaluable support to naval systems and resources. As a result of improved technology for gathering these data, both the quantity and quality of information collected have greatly increased over the years. The need for supporting multidisciplinary use of these databases has driven an ever-widening use of the technology available in Geographic Information Systems (GIS). The GIS serves as a unique environment in which data can be fused to support a wide range of applications. More recent developments in the areas of network communications, distributed database architecture, and client-server functionality have served to dramatically expand these capabilities. Network software tools, like the World-Wide Web and MOSAIC access software, provide exciting catalysts to the affective implementation of GIS within Navy operations.

The Naval Research Laboratory's Mapping Sciences Section, Code 7441, is conducting ongoing research in the Navy's development and use of GIS technology. A major component of this research is the examination of data accuracy and quality in relation to the integration of multisource spatial data sets. The identification and correction of errors and conflicts associated with the integration process is the primary focus of the SHOre-zone data RESolution (SHORES) research effort. SHORES also serves to develop an Integrated Master Database (IMD) inclusive of the Littoral Warfare Training Complex (LWTC) and Mid Atlantic Bight (MAB) regions of the Eastern United States. This document reports Code 7441's accomplishments in establishing a GIS-based Internet Mosaic Home Page environment to support the SHORES research effort. It serves as the mechanism for implementing a security review of this system prior to its implementation as an online Internet information resource.

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Mapping, Charting, and Geodesy (MC&G), coastal, littoral, standard, deconfliction, imagery

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The Development of a World Wide Web Site for the SHOre-zone data RESolution (SHORES) Program

Section 1.0 Introduction

1.1 Background Information

The use of spatially referenced scientific and operational data has provided invaluable support to Naval systems and resources. As a result of improved technology for gathering these data, both the quantity and quality of information collected have greatly increased over the years. The need for supporting multi-disciplinary use of these databases has driven an ever-widening use of the technology available in Geographic Information Systems (GIS). The GIS serves as a unique environment in which data can be fused to support a wide range of applications. More recent developments in the areas of network communications, distributed database architecture, and client-server functionality have served to dramatically expand these capabilities. Network software tools, like the World-Wide Web and MOSAIC access software, provide exciting catalysts to the affective implementation of GIS within Navy operations.

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1.1.1 SHORES Support to Coastal Scene Description

SHORES serves the Office of Naval Research (ONR) 6.2 Coastal Scene Description (CSD) program by providing participants with direct access to various types of digital mapping, charting, & geodesy (MC&G) data. Because CSD scientists from numerous disciplines are sharing large quantities of spatially referenced data, the Naval Research Laboratory's Mapping Sciences Section, Code 7441 has been tasked by the CSD program manager to provide a means of integrating and deconflicting data within a common Geographic Information System (GIS). SHORES serves to provide a unique environment in which data of varying source, type, and resolution can be fused into a single integrated database.

1.1.2 Internet and the World Wide Web

The World Wide Web (WWW) has become a resourceful mechanism for controlling the access and distribution of information stored on the Department of Defense Internet. Through the use of the Hyper-Text Mark-up Language (HTML) protocol, expansive amounts of data have been

organized for broad-level access on the Internet. HTML provides a fast, relatively easy method of linking text, graphics, and spatial data within the easy-to-use Mosaic network Graphical User Interface (GUI) which was developed by the National Center for Super Computing Applications (NCSA). Through Mosaic, the user can utilize HTML graphical links to numerous data sites, and or provide localized access to their own distributed data and information. Each of these levels of access are generally governed by the use of an HTML Home Page. Access to site-specific Home Pages is usually accomplished through the execution of a command which identifies a unique network address called a Uniform Resource Locator (URL). Direct access to Mosaic executable code, libraries, and the NCSA Home Page can be accomplished via the WWW by connecting to the following URL:
"http://www.ncsa.uiuc.edu/GDG/Software/Mosaic/NCSAMosaicHome.html".

1.2 SHORES Home Page Design Requirements

Through the development of a SHORES Home Page, CSD participants will be provided with direct access to spatial data, graphics, and documentation stored within a SHORES IMD. Thus, users will have the flexibility of viewing, selecting, and retrieving actual data sets and meta information (i.e., descriptive information) needed to conduct their specialized task within the CSD mission. The SHORES IMD will remain on-line to allow users the opportunity to integrate application specific data through the use of tools that identify and correct errors and conflicts. SHORES strives to educate the user about these problems which often occur as a result of combining multiple spatial data sets.

1.3 SHORES Home Page Implementation

Several criteria must be met in order for the SHORES Home Page to allow full access to the SHORES IMD. A primary issue is the creation of a Web Server which allows for the execution of client/server interactions within the Internet WWW structure. Through the Hyper-Text Transfer Protocol (HTTP) server environment, a communication protocol established between the local environments and other Web sites, direct execution of Mosaic operations can be established via the local host.

1.3.1 Server Environment

The local server utilizes the HTTP Daemon (HTTPD) as a local executable to establish connections between the host computer and other offsite Web resources. This connection is being established on the local NRLSSC Name server as "**gisresearch**".

1.3.2 User Access

User access to the SHORES web site is accomplished within the Mosaic environment by connecting to URL "**http://gisresearch.nrlssc.navy.mil:3220**". Access could also be established by connecting to the NRLMC&G server at "**http://www7440.nrlssc.navy.mil**" and clicking on the GIS Home Page icon. Once in the GIS Research Home Page, the user can then select the SHORES icon to implement the SHORES Mosaic application. Due to the limited distribution status of some data products used in SHORES, this level of the GIS Home Page is password protected. Potential users may contact the SHORES Principal Investigator at (601) 688-5224 or

DSN 485-5224 to establish a Mosaic user and password account.

Section 2.0 Approach

NRL Code 7441 established the SHORES Home Page as a mechanism for exchanging spatial data among CSD participants. Therefore, the functionality of the Home Page is concentrated upon three significant aspects: (1) Program Documentation and Demonstration; (2) Data Integration Processes; and (3) Data Exchange. Each of these aspects are represented within the SHORES Home Page as an individual hypertext or graphic link to a set of software tools. The following sections describe each of these tools and defines the hardware/software requirements for using each of them within the Mosaic environment.

2.1 Systems Configuration

The SHORES Mosaic HTML Home Page was developed on a Silicon Graphics, IRIS Crimson. It utilizes the Open Graphics Library (OpenGL), and is currently operating IRIX System V, Version 5.22. Although users can access SHORES via other UNIX platforms, (e.g., Sun, HP) several SGI software dependencies may limit portions of the SHORES functionality, (e.g., 3D manipulations, dynamic fly-through, and movie loops). Since most of the CSD users operate on SGI platforms, these hardware limitations have not proven to be a major difficulty.

2.1.1 Connectivity to Software Tools

SHORES software development efforts have been designed to take advantage of both Commercial Off-The-Shelf (COTS) and Government Off-The-Shelf (GOTS) software environments. As a 6.2 research effort, SHORES software development does not follow a formal configuration management program. However, substantial efforts have been taken to utilize GOTS software whenever possible. Each of the COTS development tools utilized by SHORES allows for the creation of scripts or macros which organize data and GUI functions around user requirements. These scripts and GUIs are considered to be GOTS, and are available by request through the SHORES Program Manager.

The following sections describe the COTS software environments used by SHORES, and further explain its functionality within the SHORES Mosaic Home Page environment. URL addresses for obtaining documentation on GOTS software used within SHORES includes: 1)the MC&G Utility Software Environment (MUSE) **http://www7440.nrlssc.navy.mil**; 2)Army Corps of Engineers Geographic Resources Analysis Support System (GRASS) **http://www.cecer.army.mil/grass/GRASS.main.html**; and 3)Geo-BASE ARCMacro Language (AML) Tools **http://gisresearch.nrlssc.navy.mil**.

2.1.1.1 ARC/INFO 7.0 and ARCView 2.0

Environmental Sciences Research Institute, (ESRI) developed the ARC/INFO GIS to support a wide variety of Earth Science applications. Currently, Version 7.0 offers a broad basis of spatial analysis tools, and provides a exceptional level of coordination to the input, organization, retrieval, analysis, and output of spatially referenced data. Its companion GUI, **ARCView 2.0** provides an exciting set of software tools and an object-oriented high-level programming

language in which to develop user specific query and visualization functions.

ARC/INFO and **ARCView** serve as the primary GIS for SHORES. A GOTS GUI called the Geo-Basic ARC Support Environment (Geo-BASE) has been developed by NRL Code 7441 to support its ongoing archival and retrieval of spatial data. Geo-BASE can be executed through the SHORES Mosaic Home Page. Although the **gisresearch** server will support direct access of NRL's limited number of **ARC/INFO** floating licenses, NRL recommends that the user have a local **ARC/INFO** license, since Code 7441 customers receive priority use of the license seats.

2.1.1.2 Polyview

Polyview is a 3-Dimensional data visualization and rendering tool developed by NCSA. Its ability to read data in the Hierarchical Data Format (HDF) V-set format, provides SHORES with an excellent tool for viewing exported data. Thus, data being transferred to CSD users can be verified prior to final exchange. The SHORES Home Page uses **Polyview** as an executable tool within the 'Data Exchange' module. Since system response times via the Internet are not acceptable for true 3D rendering operations, it is required that the **Polyview** software be compiled on a local user's machine. **Polyview's** dependency upon the SGI OpenGL protocol dictate that only SGI users of SHORES will be able to execute those SHORES function dependent upon Polyview.

2.1.1.3 SHOWCASE

SHOWCASE is also an SGI dependent COTS software package designed to support presentation graphics operations. SHORES Home Page uses **SHOWCASE** to display a set of slides within its demonstration tool. The pre-stored slides help to define the primary scope of the SHORES program. **SHOWCASE** provides software to sequence through each of the slides as a tutorial to the issues and problems encountered during spatial data integration processes. Since **SHOWCASE** is SGI-dependent, Sun platform users of SHORES view a set of Sun Raster Image formatted slides.

2.1.1.4 Performer

SGI's **Performer** 3-D Fly software allows for more intensive viewing of spatial data sets. Code 7441 is currently developing utilities to allow SHORES users to manipulate 3-D data while maintaining spatial referencing to the corresponding features within a relational data base. This will provide a unique ability to conduct en-route queries of spatial features during data fly through operations. **Performer** is also SGI dependent, therefore SHORES functions utilizing this capability will require a local license seat of the **Performer** software .

2.1.1.5 MoviePlayer

MoviePlayer is available on either the SGI or Sun platforms. It serves as a mechanism for storing and displaying bit-mapped images in a movie sequence. SHORES uses **MoviePlayer** to build on-the-fly routes and strip chart sequences to emulate charting software operations. The display of navigation charts and other scanned map images can be manipulated to depict ship, aircraft, and other vehicle operations according to predefined routes.

2.1.1.6 XV

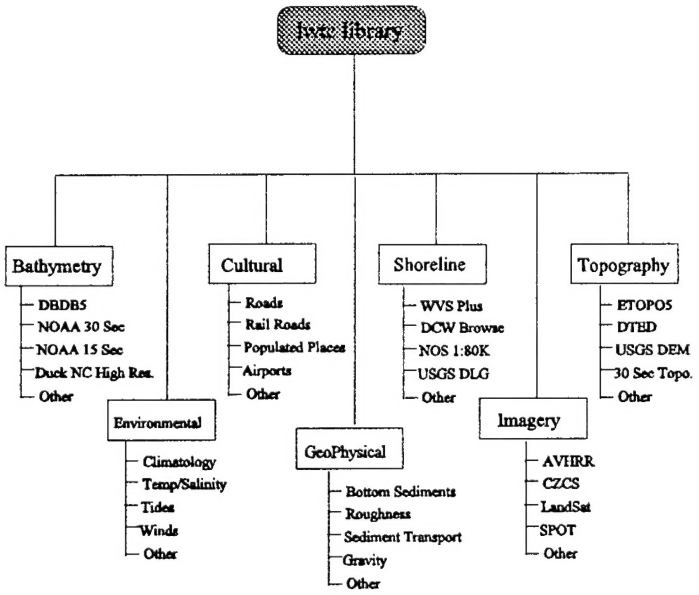
XV is an exceptionally robust image viewing package who's real benefit often lies in its ability to read and exchange a wide variety of image file formats. XV is shareware copyright software developed by John Bradley, University of Pennsylvania and runs on both the SGI and Sun platforms. SHORES utilizes XV to support data exchange of many of these image file formats.

2.2 Database Configuration

SHORES utilizes the ARC/INFO GIS as its primary means of storing and accessing spatial data sets. The data is generally stored within a hierarchical file system storage format. Each unique data theme is stored as a separate data coverage. Coverages are then stored within libraries as individual thematic layers of data.

2.2.1 Primary Data Structure

Figure 2.1 represents a hierarchical structure of the libraries and thematic coverages stored within the SHORES Master Library.



2.2.2 Meta Data Implementation

SHORES also utilizes meta data which depicts information concerning the lineage, accuracy, and other historical parameters of spatial data. Through an ARCView-based HTML environment, this data is hot-linked to areas of the Home Page which are most likely to be used to query spatial data attributes, (e.g., data exchange module). The SHORES meta data can be used to develop

data selection criteria, (i.e., all data collected after 4/27/95), and to examine a series of key parameters which help to define the uniqueness of a data set. Although the meta data must be populated at the time of data input, it offers a unique capability to use value added information throughout the data integration and analysis process.

Section 3.0 SHORES Home Page Functionality

The following sections offer functional description of the various components of the SHORES Home Page environment. The appendix offers color hardcopy illustrations of the primary pages found in the SHORES Mosaic document. A SHORES user entering the Home Page environment will first encounter the **gisresearch server** Home Page. This home page gives users direct access to descriptions of various NRL Code 7441 research efforts which utilize GIS technology. It also provides execution of four primary GIS and spatial data software programs. These include the ARC/INFO GIS, ARCView Spatial Data Visualization software, the Army Corps of Engineers, Geographic Analysis & Support System (GRASS) GIS, and the MC&G Utility Software Environment (MUSE). The SHORES Home Page is designed to give the user either direct access to spatial data or demonstration/tutorial information concerning GIS capabilities and research. The GIS Home Page also provides direct hot-links to other significant GIS Web-sites around the world.

The user then will select the SHORES Icon to execute the full SHORES Home Page. At this point the user has both a demonstration/documentation environment and a direct software environment to support CSD applications. Most home pages offer the user a chose of clicking bitmap graphic images, software button icons, or textual information. Blue highlighted text indicates that additional information can be accessed by clicking on the highlighted words.

3.1 Demonstration/Documentation Environment

By clicking on the opening beach image, the user can access the SHORES Demonstration/Documentation environment. This section includes both bitmapped graphic images and text documents which highlight the SHORES research efforts. Selection of the bitmap images will execute viewing of text and other graphics which explain SHORES approach to 'Data Exchange' and 'Data Integration' operations. Three software buttons also provide the user with 1) a SHOWCASE-based slide show demonstration; 2) a textual examination of SHORES original and modified research plans; and 3) the latest textual documentation on findings and recommendations resulting from the SHORES program.

3.2 Data Exchange/Data Integration

Execution of the 'Data Exchange' and 'Data Integration' software buttons on the SHORES Home Page provide the user with online interactive operation of the GIS software tools. These first two software buttons are designed to support the users identification and retrieval of application specific spatial data. Once identified, the user may request either online down loading of the data to his Internet site, or offline delivery of the selected data sets. Since the process of selecting data from an integrated, multi-thematic data library can be rather intensive, depending on the volume of data requested, these SHORES software utilities provide online help, documentation, and

software supervision.

The benefit of the Mosaic hyper-text environment is evident during these operations. A much less obvious benefit is the use of client/server architecture which allow the online interdependent execution of multiple software modules through the Mosaic GUI. This allows for the cooperative execution of ARC/INFO, ARCView, and other independent modules so the user can select hyper links without having to understand the parent software packages.

3.3 Error Analysis and Deconfliction

The 'Error Analysis' and 'Deconfliction' tools can also be accessed directly through the SHORES Home Page. These utilities include mutually dependent software functions to first analyze, identify, and then repair errors and conflicts resulting from the integration of spatial data of multi-sources, resolutions, and formats. These modules depend directly upon the processing of meta information within the SHORES Master Data Library, as well as various GIS spatial statistical tools.

Section 4.0 Conclusions

The Mosaic HTML environment offers an exceptionally encouraging method of fusing vast amounts of text, graphics, and software executables to support research in spatial data analysis. The client/server environment allows for a relatively easy way of building a GUI to support the online access of these data for completing research efforts requiring the shared efforts of numerous scientists and technical personnel. Mosaic provides an integrated processing environment which serves as a catalyst to the ongoing research of the Coastal Scene Description program.

Section 5.0 Acknowledgements

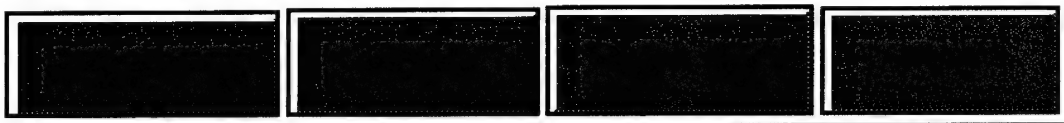
These efforts are being conducted under the direction of the Office of Naval Research, Coastal Scene Description program, Program Element and Project: 0602435N/R035E320. Dr. George Heburn serves as the NRL Program Manager. His support of the SHORES effort has been greatly appreciated.

Appendix A. Hard Copy of SHORES Home Page

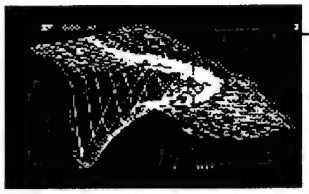
GIS & Spatial Data Research

Conducted by the Mapping Sciences Section,

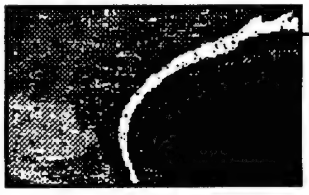
NRL Code 7441



GeoBASE Basic Analysis Support Environment



SHORES Identification and Resolution of Spatial Data Errors



MSDDB Navy Requirements for a Standard Seafloor Digital Data

MIWTIMS GIS Support to Mine Countermeasures

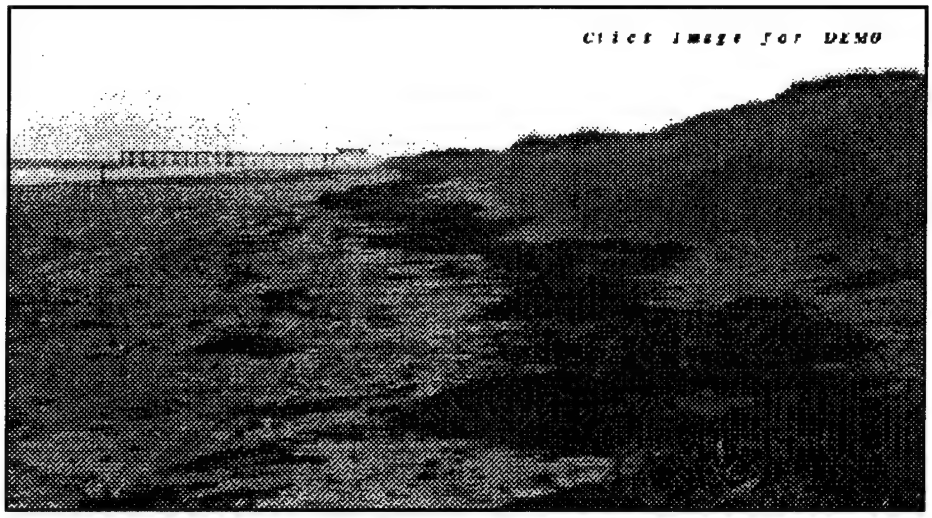
(MCM)

DNCSL Digital Nautical Chart Supplemental Layer

Other GIS – Spatial Data Related WWW Sites

- Australian Environmental Resources Information Network
- Delorme Mapping
- Demography & Population Studies Server (ANU)
- Digital Relief Map of the U.S.
- EROS Data Center
- Geographic Information and Analysis Lab
- Geographic Information System - GIS
- Geographic Resources on the Internet
- Global Land Information System
- Graphical Information Map Tutorial
- Interactive Weather Browser
- Landsat
- Natural Resources Canada
- The Australian Region
- The Virtual Tourist Web
- U.S. Bureau of the Census
- UNC Institute for Transportation Research and Education
- United States Geological Survey-HTTP Server-Home Page
- WWW del Peru-Red Cientifica Peruana
- Xerox Map Viewer
- GIS Web at Trondheim, Norway
- What is GIS?
- Texas Natural Resources Information system
- CIA Information
- United State Geological Survey Home Page

SHORES : SHOre–zone data RESolution



SHORES Program Information

Research Overview

Click on picture above or options below.

- General Info. (slide show)
- Research Documentation
  - Research Plan
  - Research Documentation
  - Findings
- Demostration Environment

Software Environment

- Data Exchange
  Provides interactive selection and transfer of digital MC&G data sets for MAB/LWTC regions. Click here for documentation or data exchange button above to execute software.
- Data Integration
  Provides methods for integrating multi–source/multi–resolution MC&G data with user specified data. Click here for documentation or data integration button above to execute software.
- Error/Conflict Analysis
  Provides methods for indentifying errors and conflicts associated with data integration. Click here for documentation or error analysis button above to execute software.
- Deconfliction Tools
  Provides methods for resolving errors and conflicts. Click here for documentation or deconfliction button above to execute software.

References

- Data Reduction and Error Analysis for the Physical Sciences

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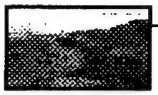


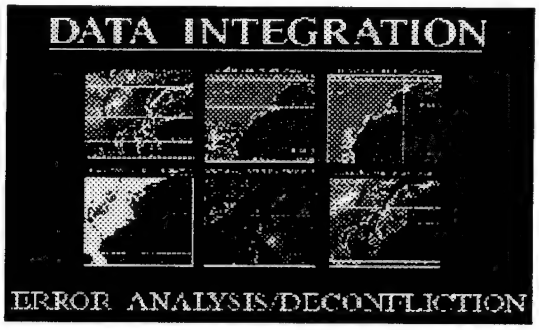
Return to SHORES HomePage

Return to GIS Research HomePage

SHORES Demonstration Environment

The SHOre–zone data RESolution (SHORES) research effort provides two primary levels of digital Mapping, Charting, & Geodesy (MC&G) data support for the Coastal Scene Description (CSD) 6.2 research program. The SHORES research plan indicates these levels consist of 1) Digital MC&G Data Exchange for the Mid–Atlantic Bight and Littoral Warfare Training Complex (MAB/LWTC) Regions; and 2) Spatial Error Analysis and Deconfliction Support for Data Integration.

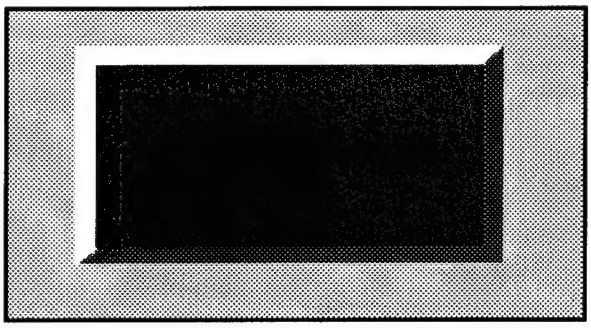
SHORES is sponsored by the Office of Naval Research (ONR) under CSD program element #R035E32, and is directed by Dr. George Heburn, NRL Code 7322.



Return to SHORES HomePage

Return to GIS Research HomeP age

SHORES Overview



SHORE–zone Data Problems

1. Geographic Region of Interest
2. Area of Support
3. Differences in Shoreline Databases
4. Differences in Shoreline Resolutions
5. Shoreline Datum Shifts
6. Differences in Databases Attribution and Relative Feature Placement
7. Significant Data Gap in Shallow Water Region
8. Shoreline Gravity Slide
9. Shoreine Image
10. Shoreline Shifts
11. Differences in Vertical Datums
12. Differences in MultiShoreline Resolutions

Return t o SHORES HomePage

Return to GIS Research HomeP age

6.2 Coastal Scene Description:

Program Element R035E32
Naval Research Laborator, SSC, MS
SHOre-zone data REsolution System (SHORES)
Research Plan

prepared by:
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14 February 1995

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ABSTRACT

The SHOre-zone RESolution (SHORES) research effort provides direct digital Mapping, Charting & Geodesy (MC&G) support to the Coastal Scene Description (CSD) program through the delivery of integrated, deconflicted spatial databases for the Mid Atlantic Bight (MAB) and Littoral Warfare Training Complex (LWTC) regions. In addition, SHORES investigates the basic research issues involved in the process of bringing together multi-source, multi-resolution spatial data to provide integrated MC&G databases. This paper defines the SHORES basic plan of research for examining the most common types of errors and conflict associated with the data integration process. It identifies a methodology for categorizing these conflicts and developing identification and deconfliction tools to support naval spatial data users. The SHORES effort is funded by the **Office of Naval Research (ONR)** under CSD program element R035E32 and is designed to offer CSD participants easy access to a myriad of standard and non-standard digital spatial databases. SHORES provides data integration support through a series of data conflict analysis and deconfliction tools within a standard GIS environment. This document outlines the approach being taken by NRL Code 7441 to complete these efforts.

Objective/Purpose:

SHORES serves the CSD through a two fold research effort which includes (1) the collection, formatting, and transfer of multi-source, multi-resolution digital spatial data sets for the MAB/LWTC regions; and (2) the investigation, identification, and correction of common errors and conflicts associated with the integration of these data sets.

Goodchild, (1989) encourages the need to make the GIS user community aware of issues concerning the accuracy of spatial data. He supports the development of tools which allow spatial data hangling systems to be used in ways which are sensative to error. In general, GIS databases are used with little regard to the underlying accuracy of the component data sets, and spatial error modeling remains unaccessable to the general user (Ehlschlaeger and Goodchild, 1994). SHORES attempts to remidy this problem by analyzing incoming data sets through both intuitive and non-intuitive error analysis routines to identify and correct conflicts within original single source data and those errors resulting from the fusion of two or more data sets.

Background Information

Database Integration:

The advancement of technology in the fields of Automated Mapping (AM), Geographic Information Systems (GIS), and Spatial Data Analysis has provided significant advantages to various industries and applications. As computer equipment and software have advanced in there capacity and speed, so also have spatial databases increased in their ability to accurately describe real-world phenomina. Advancements in collection methodologies have contributed to what is now a plethora of spatial data capable of being merged together to form integrated spatial databases. Because the methods of collection, accuracies, resolutions, and the descriptive information contained within these data can vary greatly, this integration process can generate significant errors and/or conflicts. These problems are then transferred to the end- user

application and subsequently endanger the decision processes for which the data are intended.

Error Analysis:

Buttenfield (1993) presents a substantial examination of common definitions for the concept of error, and deferentiates it from the term accuracy. In general, she defines error as relating an observed value to the true value of a condition, and illustrates the dependency of this observation on the precision at which it is being observed. She further associates the examination of error within a spatial context as being dependent upon a best logical approximation or representative sampling of the true value (i.e, the real world). Therefore, spatial error can be characterized as being the amount of difference or variance that is observed between a spatial feature measurement and its the real world entity. Buttenfield goes on to identify the difficulty of obtaining that real world measurement, and accepts the concept of data quality as being the appropriate way of representing both spatial data accuracy and error.

Since SHORES efforts are focused primarily upon the measurement of the error coponent of spatial data, spatial error will be defined as the observed difference between a measurement of a spatial feature and the best observed measurement of the real world feature. Subsequently, SHORES will always define the error of one spatial data set in relation to the accuracy of another similar data set containing the similar spatial features. The benefits of SHORES error research will support the incorporation of data quality information within a meta data processing environment.

Types of Data Error:

In general, the two primary types of data stored within a spatial database consist of geo-positional data and feature attribution data. Veregin, (1989) distiguishes the error associated with these data as being either "measurement" or "conceptual" in nature. Other authors relate these most common forms of spatial data error to both numerical and categorically constituants of the data, while Bedard (1987) refers to them as "locational" and "descriptive" error. Bedard further defines these error as being qualitative, when representing nominal and ordinal data, and as quantitative error when associated with interval and ratio data. SHORES accepts the concept that error occurs in reference to both the "quantitative" and "qualitative" elements of spatial data as its fundimental basis for defining spatial error. This definintion seems to support the concept that relative and specific geo-position data is always quantitative in nature, while attribute or feature descriptive data can refer to either qualitative or quantitative aspects of the data.

Error Within Coastal Databases:

The integration of data found within the coastal or shore-zone region is particularly responsive to these errors and conflicts because of its highly transitional nature. Within a very limited spatial dimension, data representing oceanographic, terrain, and atmospheric phenomina must be blended in a manner which compliments the definition of the coastal scene description. Conflicts in horizontal and vertical datum, projections, feature nomenclature, and feature placement introduce significant difficulty into the data integration process. Methods for readily identifying and correcting these errors and conflicts must be developed

to ensure that end-users of the CSD are provided with an accurate and timely digital representation of the littoral environment.

The Nature of Data Integration

Base Map Control

During the 1970s and 1980s, the majority of spatial data integration was performed during the data compilation and digitization phases of spatial data projects. Base maps and mylar overlays were usually designed according to themes or subject areas, (i.e., soils, vegetation, streams). These themes were then digitized and stored in seperate data partitions which were later combined or integrated using overlay and map algebra functions to view and analyze them in relation to each other. Because the data were compiled to a common base map, most errors and conflicts were discovered and corrected during the compilation process. However, with the advent of higher capacity data storage, faster computer cpu and more advanced data processing environments, (i.e., GIS), data from many compilation sources are being merged together into common databases. Regretably, this relative ease and technical simplicity of being able to reformat different data sources into a common GIS perpetuates the avoidance of data quality checking which serves to identify the operational limits of data.

Data Issues:

Each of the CSD participants have particular hardware and software requirements for working with digital^M spatial data. These include:

- Naval Research Laboratory, Codes 7322 & 7441, Stennis Space Center, MS 39529
  POC: George Heburn & John Breckenridge
  Silicon Graphics, Sun SPARC 2 & 10, and HP9000, using ARC/INFO GIS

- Applied Physics Laboratory/Univ. of Washington, Seattle, WA
  POC: Bobby Miamota and Keith Kerr
  Silicon Graphics, Sun SPARC using ARC/INFO GIS

- John Hopkins/Applied Physics Laboratory, Laurel, MD
  POC: David Scheerer Sun SPARC, other

- Rutgers University,
  POC: Scott Glenn

- Harvard University
  POC:

Each of these participants have particular hardware and software requirements for working with digital spatial data. Many are using the ESRI ARC/INFO GIS, while others are utilizing GRASS and other generic spatial processing environments. This broadness requires SHORES to provide a rather diverse environment for database exchange. At present data formats utilized by the participants include ARC, GIS and LAN, GRASS GIS, HDF, ASCII, VPF, and MUSE. Although each of these formats should be supported within the context of SHORES, the HDF seems to be the one most commonly used by the participants as a file exchange standard.

Multi-Source Data:

SHORES spatial data is being gather from a large contingency of Federal, State, Local Government, Private Industry, and University sources. The Defense Mapping Agency (DMA) Standard MC&G Data Products are the only ones which have undergone an official DoD review and validation process. All other products, though they represent substantial data inventories are not approved for DoD useage in official Warfare Operations. Additionally, any data sets resulting from the modification of DMA Standard Products should also be treated as unvalidated data.

Significant amounts of public domain data are available from the National Geophysical Data Center and the National Ocean Survey under the auspecies of the National Oceanic & Atmospheric Administration. The U.S. Geological Survey also offers an equally significant amount of spatial data at various scales and resolutions. Much of these data are available through the following Internet links:
http://www.ngdc.noaa.gov/mgg/gdas/gd_sys.html for NOAA NGDC, and
http://info.er.usgs.gov/data/index.html for USGS's US GeoDATA Homepage.

Multi-Resolution Data:

The resolution of a spatial data set primarily refers to the smallest single entity or element of distinction within the data set. The term generally represents either discrete features of a constant resolution, (i.e., 1:24,000 linear features) or continuously spaced features of a minimum size or constant area, (i.e., 15 second cell data). Integrating multi-resolution data refers to the process of combining two or more data sets of differing spacing or feature size into one resultant data set. This integration process is usually accomplished by using either the largest resolution data set as a constant to which other data sets are combined or interacted, or by supplementing a large coverage of a small scale or resolution data set with limited coverage from a larger scale or resolution data set.

The issue of integrating substantial amounts of multi-resolution data can make it difficult to trace the origin of a resultant database. The more common the data integration process becomes, the more apparent the need becomes fort the user to be kept aware of the effects associated with mixing these data types. Although significant data value can be added to low resolution data through the merger of higher resolution data, the user often needs the ability to differentiate between original single resolution data and multi-resolution data sets. Currently, the most effective way of informing the user of this information appears to be through the processing of meta-data information processing. Meta-data is data which contains descriptive information about actual feature data. It is expected that future SHORES efforts will address the issue of spatial meta information processing.

Technology Transfer to CSD:

The type of data access needed by the CSD participants requires that SHORES be capable of meeting a wide variety of needs for data distribution. These include providing direct on-line access to distributed data sets, as well as providing the ability to request individual data sets via magnetic media or network down-loading. Currently, the computer industry favors several common options for

distributed data access, including: On-line access through a network interface such as the MOSAIC, CD-ROM or other high volume, multi-media distribution media, or through individual requests for data dristributed on magnetic media, (i.e., 1/4 cartridge, 8mm data tape, or 4mm DDS data cartridge. The CSD participants utilize a wide assortment of hardware, software, and data processing formats, and therefore require a combination of these media to meet their needs for demonstrating and distributing SHORES spatial datasets.

Approach to Conducting SHORES Research

Primary Support Areas:

SHORES provides two primary areas of support to the CSD program: 1) Database Integration, and 2) Basic Research in Spatial Error Analysis. The Data Integration environment is designed to bring together as many spatially oriented geophysical data sets as is possible for the MAB/LWTC regions of the Eastern United States. It will focus upon delivering these data sets either as individual or integrated, and in a user format which most closely resembles that of the CSD participant agencies. During the course of integrating and distributing these data, signifincant errors and conflicts can be anticipated due to the wide variety of sources, formats, resolutions, and data structures. Since the GIS industry currently provides little user level support for error analysis and data deconfliction (Ehlschlaeger, et.al.), SHORES will conduct basic research into identifying and utilizing common, new, and innovative techniques for error analysis and modeling.

SHORES will utilize common statistical analysis techniques to analyze individual and resultant data sets to identify quantitative and qualitative data errors. GIS macro language and C++ routines will be developed to correct these errors in a manner supportive of the CSD program participants ongoing research efforts. The remainder of this document focuses upon identifying the technical approach taken by SHORES to fulfill both of these requirements.

Database Integration:

The integration of spatial data emcompasses a significant amount of effort. It is designed at ensuring that the CSD databases maintain a level of accuracy equivalent to that of the original spartial data sets. These efforts are designed to support the CSD user by providing both original and integrated data which represents the geophysical characteristics of the MAB/LWTC region. To complete these tasks, the SHORES project will depend upon a somewhat large set of software and hardware parameters, including:

ARC/INFO and GRASS GIS, NCSA Mosaic with direct Internet connection on both SUN & SGI platforms, C++ Utility Software Modules, XGraphics, Motiff, Polyview, and XView. However, since CSD participants have a broad chose of formats from which to request original and integrated data distributions, these hardware/software requirements will impose little or no impact upon the CSD user.

Error Analysis

Visualizing Data Error & Conflict:

The types of error and conflict associated with merging or fusing multi-resolution, multi-source data sets can be quite varied. For some time now, the common spatial data user has been made aware of the many errors associated with the data collection, compilation, and digitizing stages , although spatial error modelling is not generally available at the user level (Ehlschlaeger and Goodchild, 1994). The issues of introducing error and conflict into data through integration with other data sets, has proven to be a subject of much less attention.

Three primary areas of concern seem to be obvious when considering the types of data conflicts and errors induced through the data integration phase of GIS. These include: 1) Relative and Specific Positional Accuracy (i.e., Datum Shifts, Uncommon Projections, and Differences in Coordinate Precisions); 2) Qualitative Feature/Attribute Agreement; and 3) Quantitative Feature/Attribute Aggreement. The following paragraphs examine each of these areas in more detail.

Relative and Precise Positional Accuracy

Issues concerning the relative and specific positional accuracy of data are most commonly identified in relation to the geodetic control of the data. Horizontal and vertical datums, map projections, and coordinate grid reference systems are primary areas of concern when data of differing types are fused or integrated. Each of these areas offer opportunities of inducing significant error or conflict into the integrated database.

Datum shifts generally result when two or more base maps or data sets are compiled and digitized using different geodetic or relative datums. Datums serve as references of control for both horizontal and vertical measurements relative to the shape of the Earth's surface. Therefore, data which are referenced to diffirent datums will be directly subject to the amount of positional and quantitative difference between their associated datums. Although two databases may reference a horizontal feature such as a shoreline, if their associated datums differ by +-20meters, than the two shoreline features within the data sets may also incurr positional differences of the same or greater value. It must also be understood that the description of data based on these horizontal and vertical datum is highly dependent upon the representitive scale of the databases.

Quantitative Feature/Attribute Aggreement

Problems can be identified as either data errors or conflicts. Data errors represent those types of data problems in which an absolute quantitative or qualitative data value has been mis-calculated or mis-represented due to the integration of two or more data sets. In example, the creation of a continuous gridded data set from the union of a discrete hydrographic soundings data with bathymetric contour data could incur serious errors if the cell size of the new gridded data set is specified to be smaller than the horizontal accuracy of the original data.

Qualitative Feature/Attribute Agreement

Nomenclature used to describe feature attributes are directly dependent upon application specific criteria. Normally, these criteria are determined by either the data collector or the end-user. When nomenclature between two or more data sets differ significantly, this presents a conflict which happers or even prevents data query and retrieval operations. Thus analytical operations which are dependent upon these queries will either severely impacted or also prevented.

Spatial database nomenclature is generally defined with the use of data dictionaries which associate attributes with corresponding feature types. As long as these data dictionaries are present, cross referencing catalogues can be establish to determine the relationship between multiple spatial databases. However, when data sets are cross referenced in this manner, the process of determining like or similar feature elements within multi-source databases can become a phenominal task. SHORES will investigate current industry standards and new innovative methods of build multi-source feature catalogs to determine feature uniqueness and commonality.

SHORES Error/Conflict Resolution

SHORES will strive to develop software tools which support both the identification and remmediation of data errors and conflicts. Based upon the preceding definitions, SHORES Deconfliction environment will concentrate upon building utilities to aid in identifying errors and conflicts for both feature placement and attribute value information. Once identified, the user will choose between supervised, (i.e., interactive with user participation) and unsupervised, (i.e., rule-based without user participation) software utilities which to perform data deconfliction processes.

Meta Information Processing

The use of meta data to describe features and their attributes can provide significant information concerning the origin and quality of specific data. Although many GIS and spatial data producers provide generic information concerning the quality of data, few significant accomplishments have been made to incorporate meta information processing at the individual feature level. The inclusion of meta information to describe the origin, resolution, accuracy, precision, validation history, and data useage promises to provide a significant advantage to some spatial analysis processes. SHORES will investigate the inclusion of spatial meta information within all phases of error analysis, deconfliction, and integration. Results are expected to determine the value of including this information to help identify and correct disagreements between multi-source databases.

SHORES Software Environment

The primary software environment for SHORES consists of a C++, Xgraphics-based software shell which accesses a variety of public domain and commercial off-the-shelf software environments. The menu options available under the SHORES graphical user interface (GUI) are designed to take advantage of these environments to assist the user in selecting relevant spatial data sets which enhance their particular research efforts within the CSD program. Since the use of these multi-source

products requires substantial manipulation to ensure accurate fusion, the SHORES GUI will provide utilities designed to steer the user through the data integration process. Figure 1 illustrates the various software environment utilized within the SHORES GUI. Figure 2 indicates the functionality of SHORES software environment.

Schedule of Events

CSD Workshops are scheduled on a quarterly basis with the first workshop having been held October 26, 1994 at Stennis Space Center, MS. Major releases of the SHORES software and data will be scheduled to coincide with these workshops. The following schedule of workshops will provide three significant releases of the SHORES data, software, and documentation: - 26 January 95 at APL/Univ. of Washington, Seattle, WA; -26 April 95 at Harvard University, MA; and -26 July 95 at Johns Hopkins/APL, MD. Distribution of SHORES releases and data will be provided at these workshop via magnetic media or CD-ROM and will be tailored to UNIX workstation platforms.

Conclusions and Recommendations

The successful development of SHORES will depend upon significant research in the areas of spatial data integration, data error analysis, and GIS operations. SHORES offers an immediate level of support to the CSD for the dissemination of the myriad spatial data products and information which have recently become available to the research community. Completion of this program will depend upon a continued critique by the CSD users to determine the types and amount of spatial information needed to support the ongoing efforts of the CSD.

SHORES accomplishments should help to identify significant areas of research needed to bring the Navy and Marine Corps into the 21st century of spatial data handling capabilities. It is hoped that these significant issues can be addressed within other aspects of the 6.2 research arena. It is recommended that a special effort be made by all CSD participants to provide documentation concerning the types of errors, conflicts, and difficulties which are incountered during their use of SHORES. This documentation can then be used to further both the SHORES software environment and basic research into the handling of digital spatial information.

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RESEARCH FINDINGS

SHORES supports the integration and exchange of multi–source, multi–resolution spatial data for the **Coastal Scene Description Program**. The following sections describe the findings and results of 6.2 Research efforts conducted by the Naval Research Laboratory's Mapping Sciences Section (Code 7441).

Click on any of the following Section titles to view more detailed documentation for the four major research areas.

Data Exchange

NRL Code 7441 has utilized the collective efforts of several onging research projects to provide the CSD program with an intensive collection of spatial data for the MAB/LWTC region. Click **HERE** to view a listing of the MAB/LWTC database library.

The data exchange process involves a 'one to one' level data integration which is designed to either import or export base MC&G and CSD user data sets within the SHORES MAB/LWTC Master Library. This library, which is resides within Code 7441's ARC/INFO GIS, (e.g., GeoBASE).

Data Integration

Spatial data integration consists of three primary parameters:

Output Data = Input Data + Integration Processes

Each of these parameters consist of several properties. Changes in these various properties, (e.g., format, resolution, accuracy, scale, theme, etc.) of any of these parameters effects both the effort and approach to data integration. The following examples are ordered from least to most complicated in the nature of the integration process.

1. Same Type/Same Theme + Single Analysis Function = Same Type/Same Theme Output
2. Same Type/Multi–Theme + Single Analysis Function = Same Type/Multi–Theme Output
3. Same Type/Multi–Theme + Multiple Analysis Function = Same Type/Multi–Theme Output
4. Multi–Type/Same Theme + Single Analysis Function = Multi–Type/Same Theme Output
5. Multi–Type/Multi–Theme + Single Analysis Functions = Multi–Type/Multi–Theme Output
6. Multi–Type/Multi–Theme + Multiple Analysis Functions = Multi–Type/Multi–Theme Output

Examples of Integrated Data

- Pensacola 3D Bathymetry
- Pioneer Canyon 3D
  - Image
  - Fly Through
  - Movie Loop
- Onslow Beach
- Onslow Beach 3D

Error Analysis

Deconfliction

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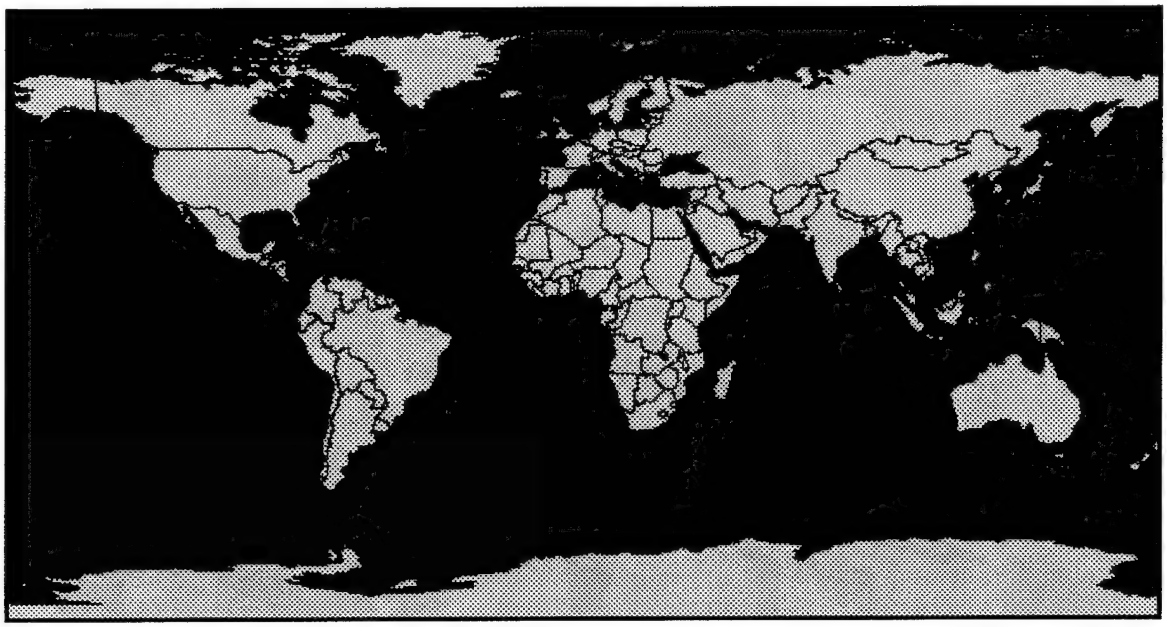


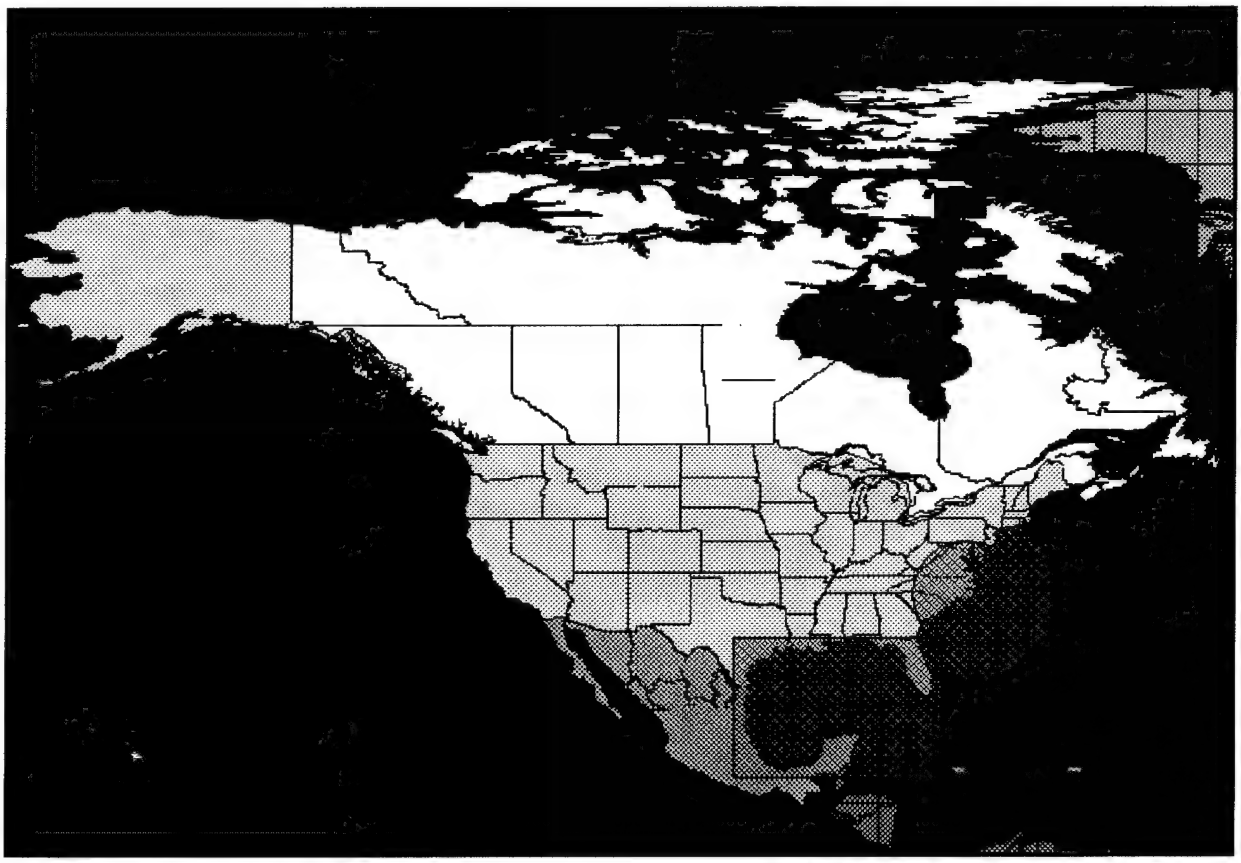
SHORES Data Exchange Facility

Naval Research Laboratory, Stennis Space Center, MS
June 16, 1995

This home page allows you to request digital data sets from NRL's Mapping Sciences Section. Fill out the necessary information below and submit your order.

The data can be directly down loaded via an ftp connection or may be processed via an Email request if tape media is desired. Since we are still testing the security of this software server, all "limited distribution" data will be forward via mail.

Send comments to **jbreck@dittohd.nrlssc.navy.mil.**



SHORES Data Exchange Facility

Naval Research Laboratory, Stennis Space Center, MS
June 16, 1995

Send comments to **jbreck@dittohd.nrlssc.navy.mil.**

Data Exchange Documentation

The Data Exchange environment of the SHORES program is designed to provide direct support to the CSD participants in the import and export of digital MC&G data within a master library. Since SHORES utilizes the ARC/INFO GIS as its primary data processing environment, all CSD MC&G information is initially **imported** into a master ARC/INFO library. Through this import process, the data sets are evaluated and modified to be consistent in each of the basic control parameters associated with digital spatial databases, (e.g., scale, resolution, projection, datums, etc.). This basic import of data into the library represents a 1st order data integration process, and provides a one–to–one execution of the integration formula:

Output Data = **Input Data** + **Integration Processes**

Once a data set has been through the 1st Order integration, it can then be exported to CSD participants in several data formats, including: Hierarchical Data Format (HDF), ASCII Text for user dependent file formats, ARC Generate or Import, and Vector Product Format (VPF).

Examples of Data Exchange Formats

- **Hierarchical Data Format (HDF)**
- **ASCII Text**
- **ARC Generate** or **Export Formats**
- **Vector Product Format (VPF)**

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LWTC

Bathymetry

Etopo5geo

5 minute gridded Bathymetry and Elevations for the world.

Topo30_relief

Hill shaded relief derived from 30 second topography.

Topo30

Elevation and depths for the 48 contiguous United States derived from USGS and National Ocean Service data. Available on NOAA Global Relief CDROM

Cape_hat

USGS 3 second DEM. Converted to grid using Arc/Info DEMLATTICE command. DEMREAD utility had to be executed first to convert the DEM from fixed length to variable length records. Grid was then projected from Decimal Seconds to Decimal Degrees.

Gravity

Na_gravity

5 minute gridded gravity for North America.

Hydrography

Us_rivers

USGS 1:100k DLG rivers for the U.S.

Shoreline

Browse

1:30m Shoreline. Converted from DCW disk from VPF to Arc/Info. Coverage is a polygon with attributes that show land and water.

Wvs

1:250k World Vector Shoreline. Coverage contains only arcs.

Eusnos80

U.S. East Coast 1:80k NOS Shoreline.

Gcnos80

U.S. Gulf of Mexico NOS 1:80k Shoreline.

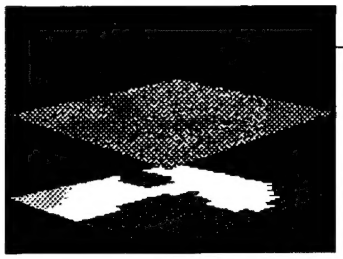
Trans

Road100k

1:100k USGS DLG Roads

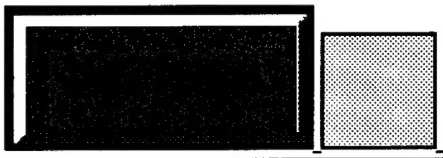
Rr100k

1:100k USGS DLG Railroads



Data Integration Process

Input Data + Integration Process = Output Data


Meta Data Environment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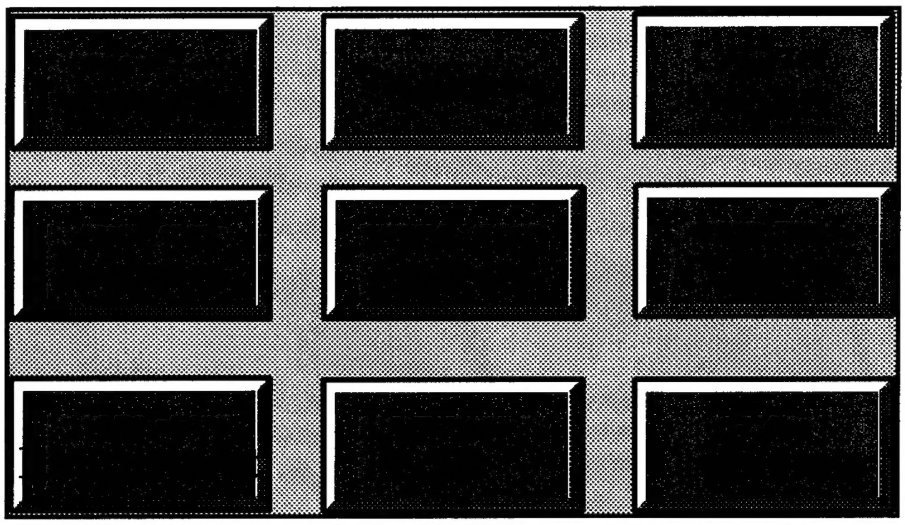
Error/Conflict Analysis Tools



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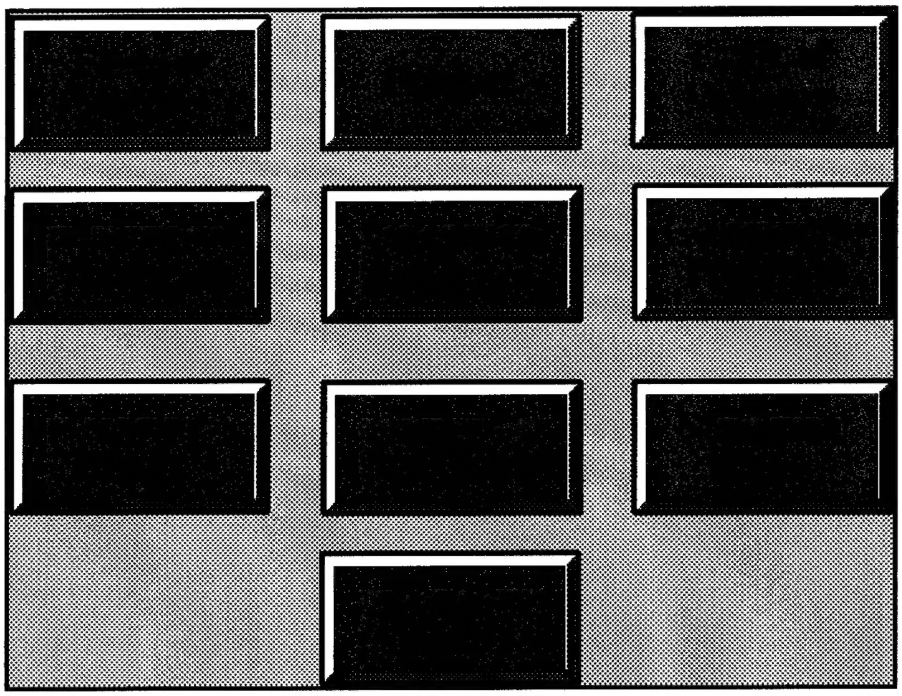
Deconfliction Tools



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